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Research on green rooftops and walls in Québec City

INTRODUCTION

The non-profit organization Vivre en ville (Vev) has as its mandate the promotion of sustainable communities. After touring successful green roof installations in Europe and North America in 2001, the staff concluded that beyond aesthetics, these "eco-roofs" offered other important advantages for urban communities. For example, the presence of vegetation has a moderating influence on the ambient temperature of the urban milieu, as well as that of the buildings' interiors, by shading and also cooling by evapo-transpiration.

Figure 1 – Start of greening the "cornice"

As a result of its study tour, Vivre en ville embarked on a green roof and green wall research and demonstration project in Québec City, at the Frédéric Back community centre, to better understand the positive impacts of these two techniques on individuals, buildings and the urban environment. The research project, supported by numerous private and public funders, considered the following potential benefits:

- energy-efficiency improvements to the buildings
  - effect of insulation by a green roof and wall in winter and summer on indoor temperature conditions
  - if lowering the indoor temperature several degrees could reduce potential air conditioning costs for the floor levels directly below the roof
- extension of roofs' service life due to the UV protection and temperature cycling reduction provided by green roofs
- assistance in the management of stormwater
- embellishment and added value to urban buildings
  - noise absorption
  - supplementary recreational space
- air quality improvement
  - effect of photosynthesis in reducing carbon dioxide
  - filtration of dust and volatile organic compounds in the ambient air
  - capture of solar heat and humidification, and cooling of ambient air, thereby contributing to the reduction of the Urban Heat Island

The first step was the design of the roof and wall support, which was complicated because the stucture of the selected buildings— former schools— built in the 1930s could not support the weight of the proposed green roof. The engineered and low-cost solution was to replace the existing wood roof structure with a ventilated system that did not exceed 90 kg/m^2 (19 lb/sq. ft.). A new ultra-light green roof concept was used to meet this criterion. This semi-intensive system employed Sopradrain, a material which acted as water barrier, root barrier, drainage and geotextile. A second lightweight material, Aquamat, used commonly in green houses to retain water for plant irrigation was also utilized.

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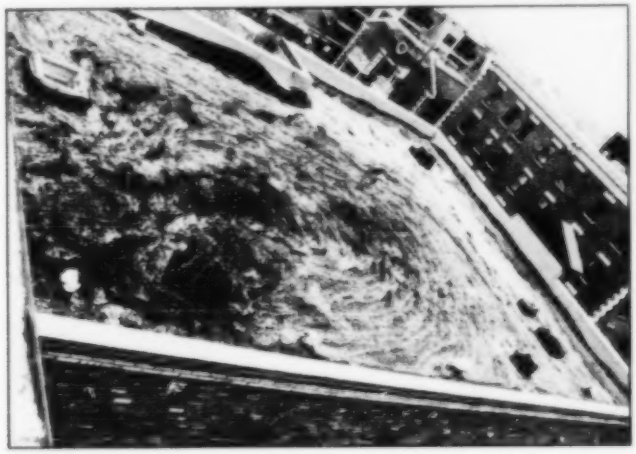

Figure 2 – First-year growth of prairie

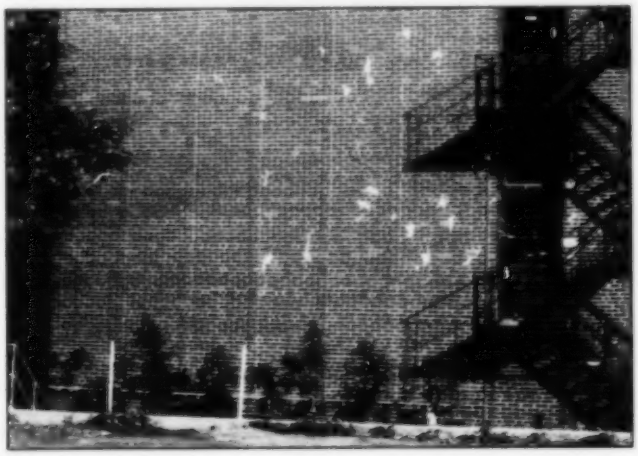

Figure 4 – Start of green wall

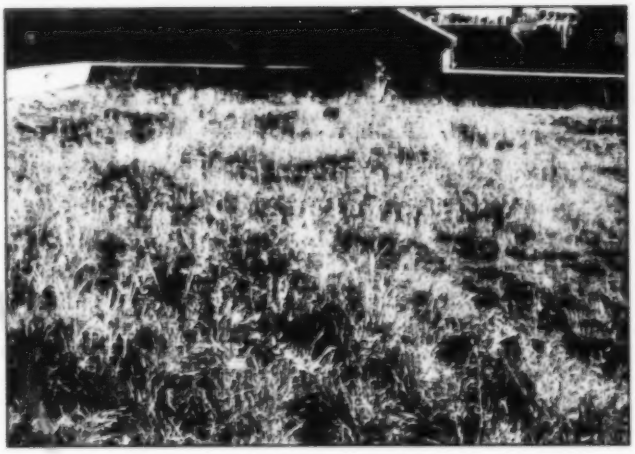

Figure 3 – Lightweight growing medium installed

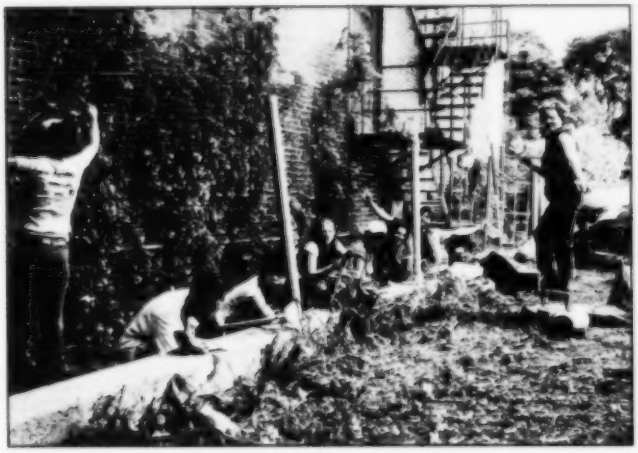

Figure 5 – Lattice installation for green wall

The plants selected included daylilies, astilbe, chives, saxifrage, *coreopsis*, white clover, centaurea, cosmos and rudbeckia. They were planted in 150-mm thick super lightweight growing medium, developed by MAGJC Inc.

A second constraint was the City's requirement to retain the wall cornice and its shadow effect, on each of the two buildings of the Frédéric Back community centre. As the new parapets were no longer sufficiently supported by the roof structure to carry a classic cornice, Vivre en ville's proposal to develop a vegetal cornice of trailing vines was accepted. The rooftop vines were maintained by horizontal cables supported by brackets which projected past the wall face. The installation work of the cornice was undertaken by 11 volunteers from Chantiers jeunesse, and it was completed within a matter of days.

A 60-m^2 green wall also supplemented this detail on one of the south-facing brick walls, intended, in the long term, to reduce the solar heating of that entire facade. The wall structure consists of stainless steel grilles suspended by anchors over the four storeys. Three different species of vines, *Quiquefolia, hydrangea petiolaris* and *campsis radicans* were planted at the base of the wall, to compare their impacts and adaptability to these conditions, which the researchers expect to be able to verify in 2009, after five growing seasons.

Vev is planning a practical guide which will explain the green roof and wall design techniques as well as construction procedures.

RESEARCH

The research objectives were to

- experiment in the application of two semi-intensive green roofs and a green wall in a severe northern climate
- measure the improvement in energy efficiency of the building envelope and estimate the reduction of greenhouse gases (GHG)
- measure the water retention capacity of the "extensive" green roofs employed
    - Three results were anticipated by reducing the amount of urban space that is covered by impermeable hard materials: slowing of water surge in overloaded combined sewer-stormwater conduits; slowed water flow and renewal of the water table, and the resultant reduced erosion around water bodies; reduction of the volumes of water needing treatment from combined sewers.
- demonstrate the feasibility and advantages of these two greening techniques for housing and retrofit in Quebec.

Contributing partners	**Contractors and manufacturers**
Agence de l'efficacité énergétique du Québec	Brière, Gilbert + associés, architects
Fédération des caisses populaires	Les Composts du Québec
Caisses populaires Desjardins de St-Dominique and Notre-Dame-du-Chemin	Québec Multiplants
Centre de l'environnement	MAGJC Inc.
Chantiers jeunesse	FBG ingénieurs
Fonds en efficacité énergétique du Québec	Plomberie Letarte
Green Municipal Funds	Contrôle technique de couvertures CTC
CMHC	Consep Inc.
	Les ateliers Plasti
	Rona
	Matériaux de construction Taïga

ANALYSIS OF RESULTS AND CONCLUSIONS

Temperature Monitoring

Roof

The temperature variations for the upper surface of the roof and underneath the roof surface were compared with the temperature in a room directly below the roof. They indicated the following results:

- Prior to installation of the green roof, the roof temperatures taken on the top surface and below the roof followed a similar parallel, high and frequent variability.
- In winter and summer after the green roof was installed, the temperatures under the growing medium were more stable than previously. For example, the seasonal maximum of 59°C at the roof surface corresponded to 29°C under the growing medium.
- During the period when the growing medium was frozen, the temperature on the top and bottom surfaces of the roof maintained similar constant minimum and maximum temperatures of around 0°C.

During winter, the average temperature difference was 15°C. This average difference is greater than that found during the summer—however, the ice layer in the substrate maintained the roof membrane temperature near constant at 2.4°C. This low constant temperature indicated that the cold green roof had only a weak thermal insulation ability.

The researchers concluded that the green roof has the greatest potential in summer, maintaining interior conditions between 20°C and 26°C. The study indicated that the insulating potential of the roof was influenced more by its ability to absorb the solar radiations than by its thermal resistance. One of its considerable advantages is the latent heat stored in the substrate's water, and its cooling potential by evaporation. In addition, the vegetation is more light reflective than the traditional dark roof.

Because in Quebec electricity is hydro-generated, a relatively small equivalent of 330kg GHG emissions would be avoided annually. In provinces generating more GHGs in their electricity production, the environmental benefits would be greater—for example 14,775 kg/kWh/year in Alberta. GHG reductions are also influenced by the reduction in water treatment and by the capture of CO_2 by the growing plants. Using one type of plant, the amount of CO_2 sequestered by the roofs could be around 5,760 kg annually.

Wall

While awaiting the results of the vines' full coverage of the south-facing walls, a preliminary analysis has shown that, an average of temperature difference in front of and behind the plants ranged from 13.9°C for the *Quinquefolia* to 11.5°C for the hydrangea and

the bittersweet. The cooling potential of the green wall was estimated at 33 per cent of the heat gain through the wall. The *Quinquefolia* was the most robust and rapid grower in addition to providing denser coverage of the wall. In the evening, the air and wall temperatures equalize, with a 1°C average difference.

The yearly GHG reductions for a green wall were estimated by the researchers at 123.2 kg/kWh in Quebec, and at over 5,500 kg/kWh if located in Alberta.

Water retention on roofs

A central roof drain recuperated the rain water runoff from the largest building—440 m² roof area. Barrels were installed on the top two floors to capture excess water that was used internally for watering plants. Data collected from July to October 2005 showed that, following dry periods, close to 100 per cent of the water was retained when a rain event deposited 5 mm of water. (In Québec City, an event leaving more than 4 mm provoked overflows of the city's sewer system before the installation of retention basins.) After a series of heavy rain events that left 18 mm of water on the roof, 98 per cent was retained, a total of 8,272 litres. Only 161 litres were gradually rejected into the barrels over three days.

This roof's ability to absorb such a large amount of water (higher than in previous studies) can be explained by the extra capacity of the capillary mat, the growing medium and the plant roots to absorb water quickly. In addition, evaporation was optimized by the incomplete vegetative cover of the medium which was relatively hot, due to sun exposure, even under cloudy conditions.

Water Quality

In spite of the 98 per cent rain retention during heavy rain storms, untreated water that could be used for domestic activities within the building—subject to provincial and municipal regulations—was recuperated. Up to 300,000 litres of water could thus be recovered. This and water absorbed by the roofs prevented water contamination by sewage overflows.

Other Criteria

The objectives of determining roof longevity and added value are being assessed over a longer period and are not reported here.

Promotion

The visibility of the demonstration site and strong media coverage helped Vivre en ville to effectively reach the public sector. The project has also contributed to develop the green industry's regional capacity, supported by Vivre en ville's, workshops, information session, articles and multi-media information kit *Vers les collectivités viables.*

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